æcteristics of the larval fish. These were the first observations made on the breeding *Umbra* and should be repeated before they are fully accepted. Although many years ago I kept several specimens in a small aquarium, no attempt to breed was noticed, and none has been observed in an aquarium of the U. S. Fish Commission containing a number of them. I therefore call attention to the interesting article by Carbonnier.

THEO. GILL.

NOTES ON PHYSICS.

THE TUNGSTEN LAMP.

MANY readers of SCIENCE may be interested to know that 'the electric lighting industry is face to face with a change of almost revolutionary character,' to quote from the concluding paragraph of a paper read before the American Institute of Electrical Engineers by Dr. C. H. Sharp, of the Electrical Testing Laboratories of New York City, on Friday evening, November 23.

The two papers of the evening were, a paper by Dr. C. P. Steinmetz on the general aspects of the problem of the transformation of electric power into light, and one by Dr. Sharp on some tests of new types of incandescent lamps; and the subject was discussed by several investigators who are working upon the problem of the tungsten lamp in this country.

It is generally conceded that within a year an electric glow lamp, the tungsten lamp, will be on the market and that the output of light per unit of power consumed will be increased at least threefold above that which is now obtained by the carbon filament glow lamp; which means that the light-producing capacity of every electric lighting station in the world will be at once multiplied by three, and that there will be at once the possibility of greatly reduced prices per unit of light and greatly increased profits to the electric lighting companies.

Those who are interested in the scientific or technical aspects of the problem of electric lighting will find it worth their while to read the papers of Dr. Steinmetz and Dr. Sharp in the forthcoming monthly issue of the *Proceedings of the American Institute of Electrical Engineers.*

NORMAL VERSUS SELECTIVE RADIATION.
SELECTIVE EXCITATION.

To obtain a highly efficient lamp is either to discover a substance which will stand an excessively high temperature under which conditions a very large percentage of the radiant energy is light, or to discover a substance which at a moderately high temperature radiates selectively and gives off a large percentage of luminous radiation. Thus the Welsbach gas light owes its high efficiency very largely to the selective radiation of thorium and cerium oxides.

The idea of selective radiation is, however, profoundly modified in most illuminants and made to depart widely from that form of the idea which is based upon thermodynamics, where the idea grows out of the necessarily complementary character (in a substance nearly in thermal equilibrium) of emission, transparency and reflection.[1]

This modification of the idea of selective radiation is so important in the problem of light production that it should be more generally recognized, and its very intimate connection with that principle in the kinetic theory of gases which is known as the principle of the equi-partition of energy should be pointed out. Indeed, this modification of the idea of selective radiation is intimately connected with the apparent inapplicability of the principle of the equi-partition of energy.

Jeans has shown that the apparent failure of the principle of the equi-partition of energy in a gas may be explained by the hypothesis that when energy is given to a gas in a particular form, say as energy of translational molecular motion, it takes a very long time for this energy to become properly partitioned among all the possible modes of molecular motion.

The application of Jeans's idea to the question of selective radiation is that when energy

[1] See Nichols & Franklin's 'Elements of Physics,' Vol. III., chapter on Radiation for an outline of the argument.

in a particular form is imparted to a substance it spreads out very slowly among the various possible modes of molecular motion and if the substance is losing energy continuously by radiation we must have a very wide departure from black body radiation because of the wide and persistent departure of the substance from thermal equilibrium. I think this departure of the radiation of a substance from black body radiation should be attributed to its actual cause, selective excitation, and it should not be spoken of as selective radiation in the strict sense of that term.

The extent to which the radiation from a selectively excited substance departs from black body radiation or rather from its own characteristic normal emission (when it is nearly in thermal equilibrium) depends greatly upon the speed at which the energy of a given mode of molecular motion spreads out into all the possible modes, and we have evidence that this speed of spreading is very slow even in many solid and liquid substances. Thus we have in the fire-fly a case of selective excitation and the wide departure of the radiation of the fire-fly from normal black body radiation shows that the energy which is developed by the selective excitation is nearly all radiated before it spreads out to any great extent among the various possible modes of motion.

In the case of the Welsbach mantle it is not at all certain that we have a genuine case of selective radiation free from the effects of selective excitation, for, although the exciting agent in this case is the extremely disordered movements of combustion, still even the disordered movements of combustion do no doubt depart very widely from the type of molecular motion which would exist in the same substance in thermal equilibrium.

When energy is imparted to a glowing substance by the electric current, whether the substance be solid, or liquid, or gas, we have in all probability a strongly marked case of selective excitation.

The upshot of this whole matter is that in the solution of the important problem of the efficient production of light we are not constrained by the thermodynamic laws of radia-

tion, and not to a very great degree dependent upon selective radiation properly so called, but we are left free in the field of unlimited possibilities of selective excitation and we may look forward with some hope of a highly efficient lamp independently of the discovery of a substance which will stand temperatures of many thousands of degrees.

In the tungsten lamp we have certainly a filament which stands a very high temperature (several hundred degrees higher than the carbon filament can stand), we have a filament which certainly shows selective radiation in the strict sense of this term, and we have most certainly some degree of selective excitation. To what extent the high efficiency of the tungsten lamp is to be attributed to one or another of these three things it is impossible to decide from present data.

In the mercury-vapor lamp and in the titanium-arc lamp we have certainly a substance (a vapor) which can stand an unlimited degree of temperature, but we know that the vapor is not very hot in either case; also in both lamps the light-giving vapor most certainly shows selective radiation in the strict sense of this term, and in both cases we most certainly have very pronounced selective excitation. Furthermore, in the case of a gas or vapor it seems that the speed of spreading out of a given mode of molecular motion into all possible modes is very slow, so that selective excitation in a vapor or gas shows itself in very pronounced departure of the radiation from the normal characteristic radiation of the given gas or vapor.

The most striking instance of selective excitation as shown by extremely abnormal radiation is that afforded by the long-continued glow of the air in a Geissler tube *at liquid-air temperature* after the cessation of the exciting current. It seems, indeed, that the lower the temperature of a substance the slower the energy of a given exaggerated mode of molecular motion spreads into other modes, and the higher the temperature the more this spreading is accelerated. A remarkable consequence of which is that a selectively excited gas should be cold to give the greatest possible luminous efficiency, whereas a very hot gas

when selectively excited tends to give off perceptible intensities of radiation corresponding to every possible mode of molecular motion.

Another aspect of increased rapidity of spreading of energy among the various modes of motion of a gas with increased temperature is that the spectrum of a very hot gas when excited by the electric current tends to show many lines that are invisible when the gas is relatively cool. Thus the spectrum of the mercury arc has no red lines when the vapor is relatively cool, but when the vapor is very hot red lines appear.

W. S. FRANKLIN.

### NOTES ON ORGANIC CHEMISTRY.

THE NITRATION OF ANILINE.

IT is generally stated in text-books of organic chemistry that aniline and nitric acid, of tolerably high concentration, yield resinous, tarry, or carbonaceous material from which no definite compounds can be isolated, whereas, in the presence of a large excess of concentrated sulphuric acid, nitration of the aniline takes place without difficulty. This behavior is explained by assuming that in the first case the nitric acid attacks the amino group of aniline more readily than it affects the benzene nucleus, but that the former is 'protected' by the concentrated sulphuric acid.

Several objections can be made to this explanation, among which the following may be mentioned: (1) Aromatic amines form stable compounds (nitrates) with nitric acid, but with nitrous acid the products (nitrites, diazonium derivatives, etc.) are, in general, highly unstable. (2) The primary products of the action of aniline on nitric acid or sulphuric acid are, presumably, aniline nitrate, $C_6H_5NH_3NO_3$, and aniline hydrogen sulphate, $C_6H_5NH_3SO_4H$, respectively, and it is not apparent why the amino group is less well 'protected' in the former compound than in the latter.

Guided by these and other considerations, we began, some months ago, a study of the action of nitric acid on aniline and on aniline nitrate, and of the behavior of certain derivatives of aniline towards nitric acid alone and

when mixed with acetic acid, oxalic acid, trichloracetic acid and sulphuric acid, respectively. The aniline derivatives employed included only those in which one or both of the hydrogen atoms of the amino group have been replaced, such as acetanilide, $C_6H_5NHCOCH_3$, or oxanilide,

$$\begin{matrix} CO \\ | \\ CO \end{matrix} \Big\rangle NC_6H_5.$$
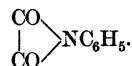
A preliminary account of our work has recently appeared,[1] and we hope to publish further communications on the subject in the course of a few months. The object of this note is to call attention to certain of our results which we think may be of some general interest. Nitric acid of any concentration up to 75.33 per cent. when mixed with aniline in equimolecular proportion forms the nitrate, provided a suitable temperature is maintained, but the slightest excess of acid, if of comparatively high concentration, changes this colorless nitrate to a reddish pink compound. This may be kept for a day or two if it remains sufficiently cool, but, more or less quickly, depending on the temperature and on the excess of acid, it darkens, blackens and may become incandescent. The color is instantly discharged by a drop of water and is regenerated by more acid.

In the formation of mononitro derivatives of the substituted anilines referred to above, the position taken by the nitro group (ortho, meta, para) appears to depend on two factors: (a) the nature of this substituting group, i. e., whether it be negative (acidic), positive (basic), or neutral; (b) the strength, not concentration, of the acid which has been mixed with the nitric acid. Should this conclusion be justified by our subsequent experiments, it will be seen that, as we can vary each of the above factors between very wide limits, the possibility is afforded of varying a in the same direction as b or in an opposite one, in order to prepare some desired isomer. Moreover, similar conditions might reasonably be expected to apply to the nitration of compounds in general, and if to nitration, then also, so far as experi-

[1] *Amer. Chem. Jour.,* **36**, 605 (1906).